

Effect of Accelerated Ageing on Paper from Cold Soda Pulp of Jute

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Jute can be used as an alternative raw material if we can produce permanent paper or archival paper from jute. To achieve this we have to assess the age or shelf life of jute based paper. The present study was carried out to study the effect of accelerated ageing by the method developed by Preservation Research & Testing Division, Library of Congress, Washington DC, USA on three different types of paper made from cold soda pulp of jute i.e., bleached paper, unbleached paper and dyed paper. The samples were evaluated for their optical and physical properties. It was observed that the bleached cold soda jute paper is highly susceptible to accelerated ageing, whereas, unbleached cold soda jute paper was less susceptible and dyed paper of bleached cold soda jute pulp was the least susceptible to accelerated ageing.

Key words: Jute fibre, cold soda pulp, hydrogen peroxide bleaching, direct dye, accelerated ageing, resistance to ageing, optical properties, strength properties

INTRODUCTION

We have a moral and intellectual responsibility not only to preserve our past heritage but also to ensure the survival of contemporary records of achievement for our posterity. As custodian of human heritage, we have the historic obligation to record our knowledge and history on durable and permanent paper. Quality of paper used in books and archives should not become yellow, fragile and brittle during lengthy storage in archives and libraries destroying written documents and printed publications. India has about 2795 handmade paper units (1) which are mainly based on cotton rags, hosiery cuttings, tailor cuttings and small quantities of waste paper. The increasing demand of handmade paper has left a big gap between the projected demand of 28000 tons in 2010 and the present production of 15000 tons (2). This gap can be reduced by introducing alternative ligno-cellulosic raw materials like jute and its byproducts.

Natural ageing is a slow process where temperature, humidity, intensity and wave length of light involved are extremely variable and not reproducible. The accelerated ageing test developed at Preservation Research and Testing Division, Library of Congress, Washington, DC, USA has been followed here. The similarity of the nature of degradation products formed under natural ageing and under accelerated ageing was demonstrated by the chemical analysis for the carbohydrate and acid species formed in ageing process (4).

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Since this test does not require the use of expensive ageing chambers that can simultaneously control relative humidity and temperature, it can be used where only simple ovens are available. Besides economy this test is also much faster since it requires only 5 days as compared to the conventional ageing tests, which generally require 30 days and even more importantly do not simulate the natural ageing process (4).

The cause of ageing is due to the acids formed as a result of the degradation of cellulose and hemicellulose as they interact with oxygen and moisture over time. The formation of these acids leads to a self-promoting hydrolytic degradation chain reaction, or autocatalysis, in which the acid concentration continually builds upon itself leading to a constantly escalating acidic environment that promotes an ever-increasing rate of cleavage of the cellulose molecule. In real life, hydrogen bonding enables retention of newly formed acid molecules within the paper matrix. The efficiency of acid retention is even higher when the paper is prevented from interaction with air as when it is situated within the body of a book, or a picture frame, or a polyester capsule (4).

Jute is an annual plant which grown mainly in West Bengal, Bihar, Orissa and Assam to the tune of about 1.5 million tons and this leaves a jute stick yield of about 3 million tons (3,6). Jute based paper being lignocellulosic in nature is susceptible to ageing which is manifested by change in color or the strength properties of the white or colored paper. Study on the effect of

accelerated ageing on jute based paper over different periods of interval has yet not been reported.

Pulp of jute waste was made by the cold soda process. The NaOH causes swelling of the hemicellulose and the amorphous region of the fibre. No reaction with lignin is likely to take place during the NaOH pretreatment, but alkali reacts with the secondary wall, thus assisting in fibrillation of the S₁ and S₂ layers (7). The cold soda pulp (CSP) was converted into three different types of paper namely: unbleached paper, bleached paper and dyed paper (Chlorantine Fast Orange TGLL). These three types of papers were subjected to accelerated ageing following the Preservation Research & Testing Division Method for different periods of interval i.e., 1,2,3,5, and 7 days. All the control and aged samples were evaluated for their optical and physical properties.

EXPERIMENTS

Raw material

Jute fibre (*Corchorus Olitorus*) was cut into 2-4 cm pieces.

Cold soda pulp (CSP)

The raw material was soaked in a 10 % NaOH solution at 1: 10 material to liquor ratio for 24 hours. The material was washed free of alkali and then beaten partially in a valley beater.

Kappa number

The Kappa number of both the

unbleached and the bleached pulp was determined by the Tappi Test Method - Tappi 236 cm-85 (5).

Bleaching of cold soda pulp

A portion of the unbleached soda pulp was bleached in a covered vessel using H₂O₂ (20 ml/l) at 1:20 material to liquor ratio, tri-sodium phosphate (5 g/l), NaOH (1g/l), sodium silicate (1g/l) and nonionic detergent (2ml/l) for 1.5 h at 85-90° C. The pH was maintained at around 10. The bleached pulp was washed in normal water and neutralized with dilute acetic acid (2 g/l) and was given a final wash for further processing.

Dyeing of cold soda pulp

The bleached pulp was dyed in an open bath at 1:20 material to liquor ratio at 90-95° C, for 1 h, with the direct dye Chlorantine Fast Orange TGLL (2 % on weight of material). Sodium sulphate (10g/l) was used as exhaustion agent. The dyed samples were washed with normal water before soaping with non-ionic detergent (5g/l) at 40° C for 30 minute and then given a final wash.

Handmade paper and standard hand sheets

Handmade paper sheets and standard hand sheets of 60 GSM were made from all the three types of pulp i.e., unbleached, bleached and dyed pulp after beating them to the standard freeness in a Valley Beater, using an auto vat and a hand sheet former of Universal Engineering Corporation, Saharanpur.

Accelerated Ageing

All the paper samples i.e., unbleached, bleached and dyed paper sheets were conditioned under standard test condition and then sealed in air tight containers and subjected to accelerated ageing in an oven at 100° C for different periods of interval 1,2, 3, 5 and 7 days.(4) The moisture contents of the paper samples before subjecting them to accelerated ageing were 8.57 %, 6.18 % and 5.71 % respectively.

Evaluation of Optical Properties

Optical properties of the paper samples before and after subjecting them to accelerated ageing were evaluated for 457 nm Brightness, Whiteness Index E 313(D65/10), Yellowness Index E 313

Table 1
Yield of jute and its various components (6)

Jute Varieties	Yield of Whole Plant Tons/hectare	Ribbon %		Dry fibre %	Leaves %		Stick %	
		Green	Dry		Green	Dry	Green	Dry
<i>Corchorus Olitorius</i>	46	38.7	11.1	6.8	11	2.7	50.3	16.6
<i>Corchorus Capsularis</i>	34	40.2	11.2	5.9	15.9	3.9	44.2	12.5

Table 2
Chemical Composition of Jute Fibre(6)

Constituents	Jute varieties	
	<i>Corchorus Olitorius</i>	<i>Corchorus Capsularis</i>
α-Cellulose	60.7	61.0
Pentosan	15.6	15.9
Lignin	12.5	13.2
Polyuronide	4.8	5.24
Acetyl value	3.5	2.9
Fat & wax	1.0	0.9
Nitrogenous Matter	1.87	1.56
Ash	0.79	0.5

Table 3
Morphological Data of jute(6)

Jute Varieties (90 day plant)	Cell Diameter μm	Lumen Diameter μm	Ultimate Fibre Length (L) mm	Ultimate Fibre Breadth (B) μm	L/B ratio
<i>Corchorus Olitorius</i>	16	6	2.37	19	124.5
<i>Corchorus Capsularis</i>	15	8	2.42	19	128.0

Table 4 : Effect of Accelerated Ageing on pH and Strength Properties of Bleached Cold Soda Jute Paper

Samples	Time days	pH	Fold No.		Tensile Index Nm/g		Burst Index Kpa.m ² /g	
				% Loss	Nm/g	% Loss	Kpa.m ² /g	% Loss
Bleached Paper	Day 0	7.60	38	-	36.70	-	3.67	-
	Day 1	7.31	37	2.6	36.19	1.3	3.31	9.8
	Day 2	7.30	33	13.15	31.72	13.5	3.26	11.1
	Day 3	5.51	16	57.8	27.57	24.8	3.14	14.4
	Day 5	6.98	2	94.7	27.34	25.5	3.06	16.6
	Day 7	7.34	1	97.3	16.34	55.4	3.06	16.6

(D65/10) and Post colour number {100x (K/S_{After Ageing} / K/S_{Before Ageing})}, K= Co-efficient of absorption, S= Co-efficient of scattering } in HunterLab LabScan XE Brightness tester.

Evaluation of Physical Properties

Tensile Index was determined by Tappi Test Method - T 404 om-87, Bursting Index was determined by Tappi Test Method - T 403 om-85 and Folding endurance of paper (Schopper type) was determined by Tappi Test Method - T 423 Om-89 (5). The instruments used were Tensile Strength Tester Veb Thuringer Industriewerk, Raunstein (Germany), Double Fold Tester, Veb Werkstoffpriuma Schinen, Leiplig (Germany) and Bursting Strength Tester by Ubique Enterprises, Pune.

pH Measurement

Paper samples (1g sample) were cut in to 2-3 mm size and soaked in 70 ml of distilled water for 1 hour, the pH was measured in Eutech CyberScan PCD 6500 apparatus (8).

RESULTS AND DISCUSSION

Jute is an annual bast fibre plant which grows to the tune of about 1.5 million tons every year (3,6). The dry fibre yield is about 6 % of the whole green plant. The main components of jute are cellulose, hemicellulose and lignin. The yield and its various components, chemical compositions and morphological data are given in Tables 1, 2 and 3. When jute is subjected to pulping by cold soda process it loses some of its components, although most of the lignin is retained to give a pulp yield of 83 %. The Kappa number of the unbleached pulp is 30.2, whereas the Kappa number of the hydrogen peroxide bleached pulp is 20.6. The bleached pulp was subsequently dyed by the direct dye Chlorantine Fast Orange TGLL. The paper samples of unbleached, bleached and dyed cold soda jute pulp were conditioned under standard testing condition and subjected to accelerated ageing (4) for different periods of time. All the aged as well as the control samples were again conditioned in standard atmosphere

Samples	Time days	pH	Fold No.		Tensile Index Nm/g		Burst Index Kpa.m ² /g	
				% Loss	Nm/g	% Loss	Kpa.m ² /g	% Loss
Unbleached Paper	Day 0	8.00	177	-	37.05	-	3.92	-
	Day 1	7.91	159	10.1	28.95	21.8	3.90	0.5
	Day 2	7.88	127	28.2	28.81	22.2	3.35	14.0
	Day 3	7.72	107	39.5	28.66	22.6	3.15	19.6
	Day 5	6.89	47	73.4	26.15	29.4	2.52	35.7
	Day 7	7.42	22	87.5	21.79	41.4	2.28	41.8

Samples	Time days	pH	Fold No.		Tensile Index Nm/g		Burst Index Kpa.m ² /g	
				% Loss	Nm/g	% Loss	Kpa.m ² /g	% Loss
Dyed paper (Chlorantine Fast OrangeTGL)	Day 0	7.69	30	-	28.23	-	3.75	-
	Day 1	7.62	26	13.3	27.46	2.7	3.34	10.9
	Day 2	7.59	19	36.6	25.26	10.5	3.12	16.8
	Day 3	7.31	16	46.6	23.65	16.2	2.94	21.6
	Day 5	7.25	15	50.0	23.05	18.3	2.89	22.9
	Day 7	6.92	9	70.0	16.01	43.2	2.00	46.6

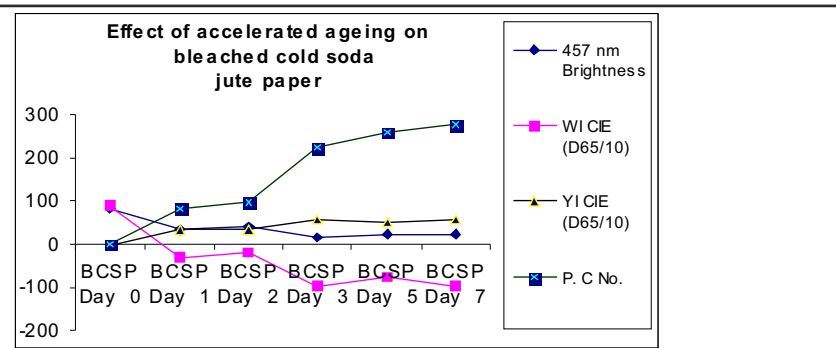


Fig. 1. Effect of Accelerated Ageing on Optical Properties of Bleached Cold Soda Jute Paper

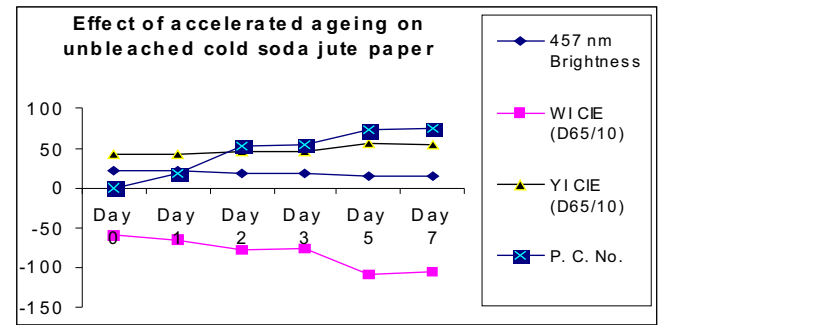


Fig. 2. Effect Of Accelerated Ageing On Optical Properties Of Unbleached Cold Soda Jute Paper

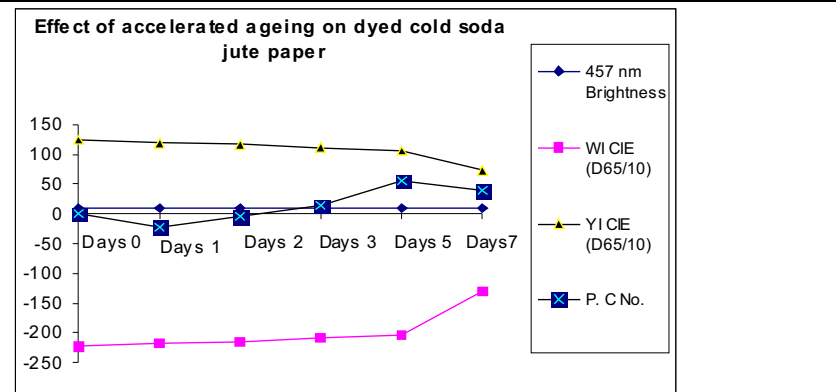


Fig. 3. Effect Of Accelerated Ageing On Optical Properties Of Dyed Paper Of Bleached Cold Soda Jute Pulp

before evaluation of optical and physical properties. The results have been analyzed and graphically represented in Figures 1-7 and Tables 4-6.

The effect of accelerated ageing on 457 nm Brightness, Whiteness Index, Yellowness Index and Post Colour Number of bleached, unbleached and dyed cold soda jute pulp is represented in Figures 1-3.

Analysis of Fig. 1 shows that in case of the bleached cold soda jute paper there was an increased loss of Whiteness and Brightness Index with increase in the period of ageing which is pronounced beyond 2 days of exposure, whereas, the Post Color Number and the Yellowness Index showed a drastic increase beyond 2 days of exposure. This indicated resistance to ageing up to 2 days of exposure in case of bleached paper made from cold soda pulp of jute. This is corroborated by the loss of strength properties which is drastic beyond 2 days of exposure and the sharp fall in the pH after 2 days of exposure as shown in Table 4 and Figs. 4-7.

In case of the unbleached cold soda jute paper, analysis of Fig. 2 shows increased loss of Whiteness and Brightness Index with increase in the period of ageing, which is pronounced beyond 3 days of ageing, whereas, the Post Color Number and the Yellowness Index showed a drastic increase beyond 3 days of exposure. Thus unbleached paper is resistant to ageing up to 3 days of exposure. This is also corroborated by the drastic loss of strength properties beyond 3 days of exposure and fall in the pH value as shown in Table 5 and Figs. 4-7. This may be due to the presence of higher amount of lignin in the unbleached paper.

Fig. 3 shows that in case of the dyed paper of bleached cold soda jute pulp, the small increase in the Whiteness Index, the small fall in the Yellowness Index and the gradual increase in the Post Colour Number is observed beyond 5 days of exposure. Thus dyed paper is resistant to ageing up to 5 days of exposure. This may be due to the presence of the direct dye in the paper. This is also corroborated by the drastic loss of strength properties beyond 5 days of exposure as shown in Table 6 and Figs. 4-7.

The effect of accelerated ageing on Fold Number, Tensile Index and Burst Index is represented in Figures 4-6. The Figures show higher Fold Number in case of unbleached paper compared to the bleached and dyed paper, this may be due to the presence of higher amount of lignin retained in the unbleached paper. The increased loss of Fold Number, Burst Index and Tensile Index beyond 3 days of exposure in case of the unbleached paper and 2 days of exposure in case of the bleached paper and 5 days of exposure in case of the dyed paper is observed.

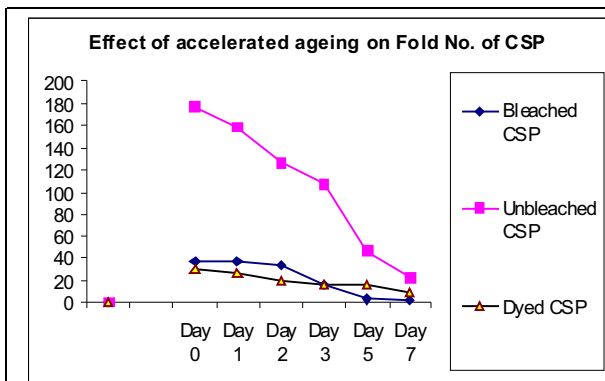


Fig. 4 Effect of accelerated ageing on Fold no. of paper from cold soda pulp of jute

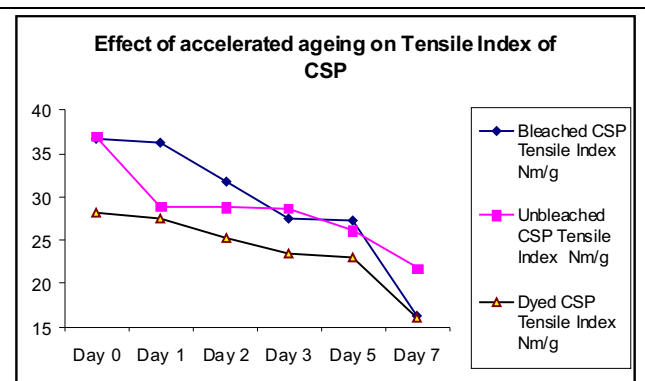


Fig. 5 Effect of accelerated ageing on Tensile Index of paper from cold soda pulp of jute

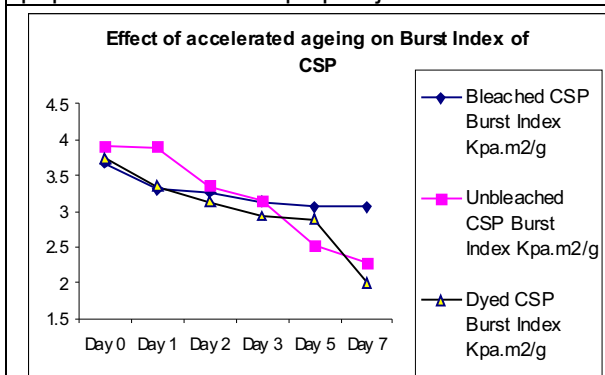


Fig. 6 Effect of accelerated ageing on Burst Index of paper from cold soda pulp of jute

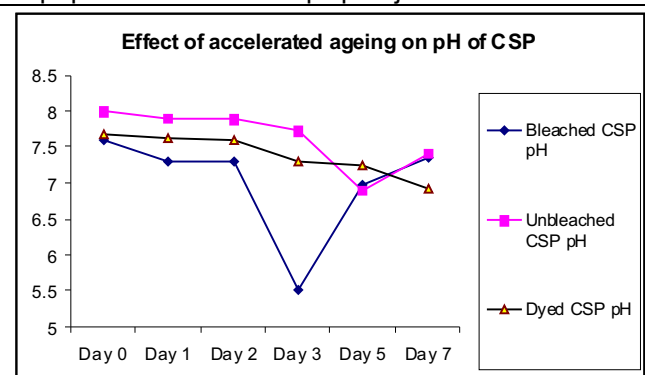


Fig. 7 Effect of accelerated ageing on pH of paper from cold soda pulp of jute

dyed paper corroborate the findings based on the optical properties.

The effect of accelerated ageing on pH of bleached, unbleached and dyed paper is represented in Fig. 7. It is observed that there is a gradual fall of pH with increase in period of exposure. The drastic fall in the pH beyond 2 days of exposure in case of the bleached paper, 3 days of exposure in case of the unbleached paper and 5 days of exposure in case of the dyed paper corroborate the finding based on the optical properties and physical strength properties.

CONCLUSION

- Bleached cold soda jute paper is highly susceptible to accelerated ageing.
- Unbleached cold soda jute paper is less susceptible towards ageing compared to bleached cold soda jute paper.

- Dyed cold soda jute pulp dyed with direct dye showed minimum susceptibility towards ageing.

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